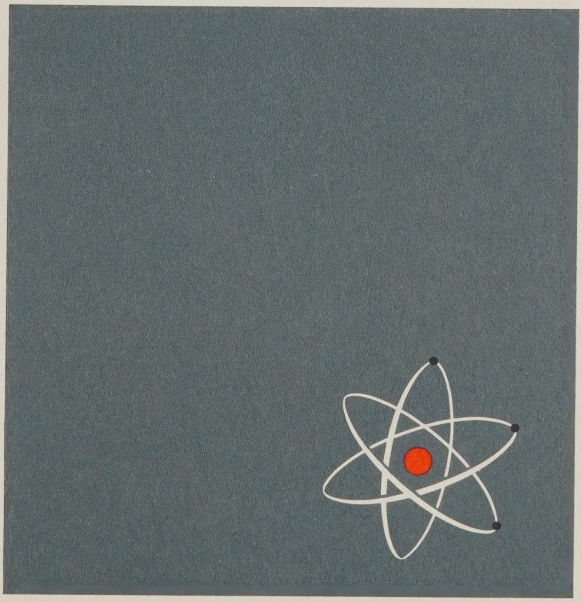
NUCLEAR RESEARCH



IN CANADA

NUCLEAR RESEARCH IN CANADA

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CANADA AND THE PEACEFUL USES OF ATOMIC ENERGY

Recent developments in Canada have increased interest around the world in the Canadian approach to nuclear power. The emergence of the Canadian nuclear power reactor, CANDU, as one of the foremost reactors in the race for economic nuclear generation of electricity was heralded at the Third International Conference in Geneva in 1964 as one of the important developments of the Conference. This development is, however, only one facet of Canada's expanding activities in the nuclear field. Here are outlined the main features of the Canadian program.

THE BACKGROUND OF CANADA'S PROGRAM

In late 1964 it became clear that nuclear electric generating stations designed now would be economically competitive with coal burning stations in Canada. Accordingly the Hydro-Electric Power Commission of Ontario announced plans to build a station with two reactors to produce one million kilowatts of electricity. In line with previous Canadian experience, the reactors will be fuelled with natural uranium, moderated and cooled with heavy water. The Governments of Ontario and of Canada have agreed to share responsibility with Ontario Hydro for the bond issues required to raise the necessary capital (about $266 million), and an application has been made to the Atomic Energy Control Board for a licence to construct the station at a Toronto suburban site on Lake Ontario. Atomic Energy of Canada Limited will be the nuclear consultant, and the estimates clearly indicate that power from this station will be cheaper than that from a coal-burning plant of the same size on the same site. The reactors are scheduled to come into operation in 1970 and 1971. They will

mark the arrival of fully competitive nuclear power in Canada. This achievement is the result of years of collaborative work by government agencies and private industry.

Three government organizations have basic responsibilities for Canada's atomic energy activities: the Atomic Energy Control Board, responsible for all regulatory matters concerning work in the nuclear field; Eldorado Mining and Refining Limited, a crown company with a double function as producer of uranium and as the Government's agent for buying uranium from private mining companies; and Atomic Energy of Canada Limited (AECL), a crown company concerned with nuclear research and development, the design and development of power reactors, and the production of radioactive isotopes and associated equipment.

The Atomic Energy Control Board, a five-man body including the presidents of the two crown companies, was set up in 1945 principally to control the distribution of fissile and other radioactive material. The activities of the Board have increased with the expansion of the Canadian nuclear program and now include all regulatory matters such as the licensing of reactors and financial assistance to Canadian universities engaged in nuclear studies.

AECL operates Chalk River Nuclear Laboratories, Canada's main atomic research and development centre at Chalk River, Ontario, and in 1963 opened a second centre known as the Whiteshell Nuclear Research Establishment on the shores of the Winnipeg River, 65 miles northeast of Winnipeg, Manitoba. AECL head office and a commercial products group are in Ottawa; a power projects group to do reactor design is in Toronto.

CHALK RIVER NUCLEAR LABORATORIES

At Chalk River there are now five experimental reactors — ZEEP, NRX, NRU, PTR and ZED-2. The number of employees is about 2,400 of whom more than 400 are university graduates.

The 42,000-kilowatt (thermal) NRX research reactor went into operation in 1947 and the 200,000-kilowatt (thermal) NRU research reactor in 1957. Both reactors have been used for nuclear power experiments, for fundamental research, for making radioactive isotopes, and for the production of plutonium from natural uranium.

With the future market for plutonium uncertain, it was decided to stop plutonium production in NRU and the reactor was shut down in November 1963 to replace natural uranium fuel rods with enriched uranium fuel rods. This change is complete, and while it reduces the thermal power (heat output) to 60,000 kilowatts, the density of the neutron flux remains high for experiments and for isotope production. The three 100-watt research reactors, ZEEP, ZED-2, and PTR, are used for purposes such as testing fuel rod arrangements for power reactors, determining the reactivity of fuel samples and studying the neutron-absorbing properties of materials.

In the many laboratories at Chalk River fundamental and applied research and development are carried out in biology, medicine, physics, metallurgy, chemistry and engineering. In addition to the research reactors, other large research machines such as a 10-million electron-volt tandem accelerator, a three-million volt Van de Graaff generator and a large beta-ray spectrometer have been in use. The tandem accelerator will soon be dismantled to make way for a 20-million electron-volt accelerator known as the MP Tandem Van de Graaff. This new machine will enable physicists to obtain new data on the arrangements of particles in atomic nuclei and on the forces which bind them together.

WHITESHELL NUCLEAR RESEARCH ESTABLISHMENT

At Whiteshell Nuclear Research Establishment the construction of WR-1 reactor is nearing completion. WR-1 will operate with organic liquids at high temperatures and will be a flexible tool for evaluating fuels and materials under power reactor conditions. The laboratories at Whiteshell will concentrate on work in the fields of chemistry, chemical engineering, fuel development and metallurgy.

POWER REACTORS

From the diverse reactor types that can be conceived for power generation, AECL chose the heavy-water-moderated, natural-uranium reactor as being the most suitable under Canadian conditions. The principal reason for this choice is that heavy water permits a very high burn-up of the fuel in a single pass through the reactor; this, combined with the low cost of natural uranium, results in a very low total fuel cost. In fact, the Canadian nuclear-power program is unique in that it aims for such a high burn-up that used fuel elements may be discarded as waste rather than put through expensive recovery processes for extraction of plutonium and unburned uranium.

NPD (Nuclear Power Demonstration), Canada's first power station at Rolphton, Ontario, operated throughout the year with a capacity factor of over 80 per cent. Meanwhile, Douglas Point Nuclear Generating Station (with CANDU Reactor) is nearing completion at a site on the eastern shore of Lake Huron. This station will generate 200,000 kilowatts and will go into commercial operation in 1965.

Studies at Chalk River have been directed towards improved fuels and different coolants for heavy-water-moderated reactors. It now appears that, if instead of heavy water, boiling natural water were used to carry heat out of the reactor, operating problems would be simplified and the cost of producing electricity would be reduced. It has

been proposed to test these hypotheses by changing the NPD reactor to operate with boiling natural water as coolant in 1966.

PRODUCTION OF HEAVY WATER

To supply heavy water for the increasing number of nuclear reactors in Canada, Deuterium of Canada Limited is building a heavy-water production plant at Glace Bay, Nova Scotia; Western Deuterium Limited is building a second plant at Estevan, Alberta. The Glace Bay plant will produce 200 tons of heavy water per year by 1966; the Estevan plant will produce 300 tons per year when it is completed.

URANIUM

Uranium continues to play an important role in the Canadian economy and is high on the list of export commodities. However, after reaching a maximum of 15,900 tons of uranium oxide in 1959, deliveries have fallen steadily, reflecting the fall in demand from Canada's main customer, the United States. Canadian production of uranium oxide in 1963 was 8,100 tons.

INTERNATIONAL

In the international field, close ties are kept with the United States Atomic Energy Commission (USAEC) and the United Kingdom Atomic Energy Authority (UKAEA), both of which have representatives permanently at Chalk River.

In 1963 AECL and the UKAEA concluded an agreement to extend their collaboration on the development of heavy-water-moderated, water-cooled reactors and their fuel. The agreement reflects increased interest in heavy-water reactors in Britain, where a heavy-water power reactor is now being built.

An agreement with the United States provides for the free exchange of all technical data on heavy-water-moderated

reactors and commits the USAEC to spend $5 million in the United States on research and development related to reactors of Canadian design.

Canada has recently signed agreements to exchange nuclear information with the U.S.S.R., Spain, and Italy and has established more or less formal collaboration with the International Atomic Energy Agency, the European Nuclear Energy Agency and Euratom as well as with France, India, Japan, Pakistan, Sweden, Switzerland and West Germany. Financial arrangements were completed with India for the reactor for a nuclear power station which is now under construction in Rajasthan State and which will be essentially equivalent to Douglas Point. Negotiations were conducted between the Government of Pakistan and the Canadian General Electric Company for the supply of a 132,000-kilowatt reactor of the NPD type.

RADIOACTIVE ISOTOPES

Canada was one of the pioneers in the application of radioactive isotopes in research, medicine, agriculture and industry. AECL Commercial Products Group processes and sells radioactive isotopes produced in the Chalk River reactors and also develops new uses for isotopes and equipment for their application. The division manufactures six models of cobalt-60 beam therapy units. More than 300 of these cancer treatment units have been installed in clinics and hospitals in 40 countries. Various portable and fixed facilities for the gamma irradiation of materials have been designed for industrial use.

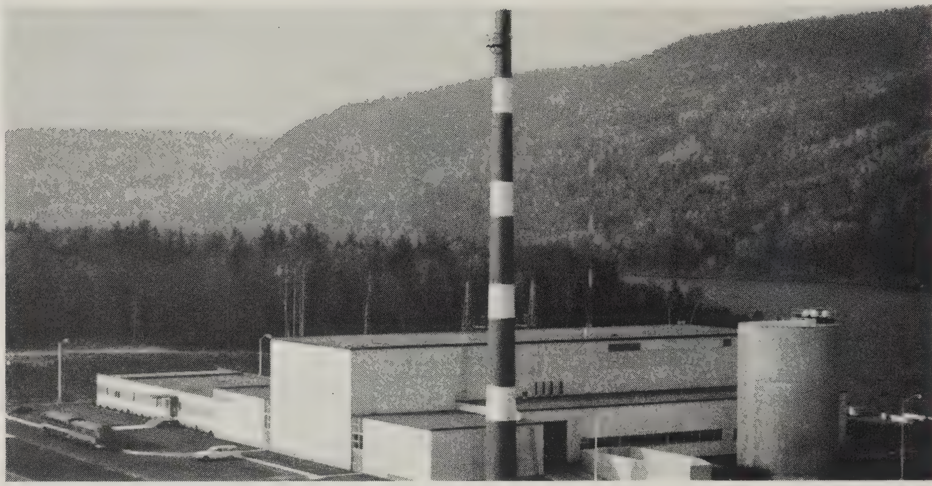
Nuclear science and technology is a growing discipline, with applications in many fields, from biology and medicine, to agriculture and engineering. Canada was fortunate to come early to this field. The combined effort of her experts in both government and industry is keeping her one of the world's leaders in all aspects of its development.

NUCLEAR RESEARCH IN CANADA

World War II saw the birth of a continuous program of nuclear research and development in Canada. In 1940 there was an exchange of atomic energy information between Britain, the United States and Canada. This was consolidated in 1942 by a joint Canadian-UK laboratory in Montreal under the direction of the National Research Council of Canada. The laboratory was later moved to Chalk River, Ontario, where a small heavy-water-moderated reactor — ZEEP — was built, to determine the basic parameters required for a much larger installation. Construction of this second reactor — NRX — was completed in 1947, and it has remained one of the world's more versatile research tools in the developing phases of nuclear power. Through interlocking development and research programs of international scale, Canada remains in the forefront of peacetime nuclear power research and use.

Whiteshell Reactor No. 1

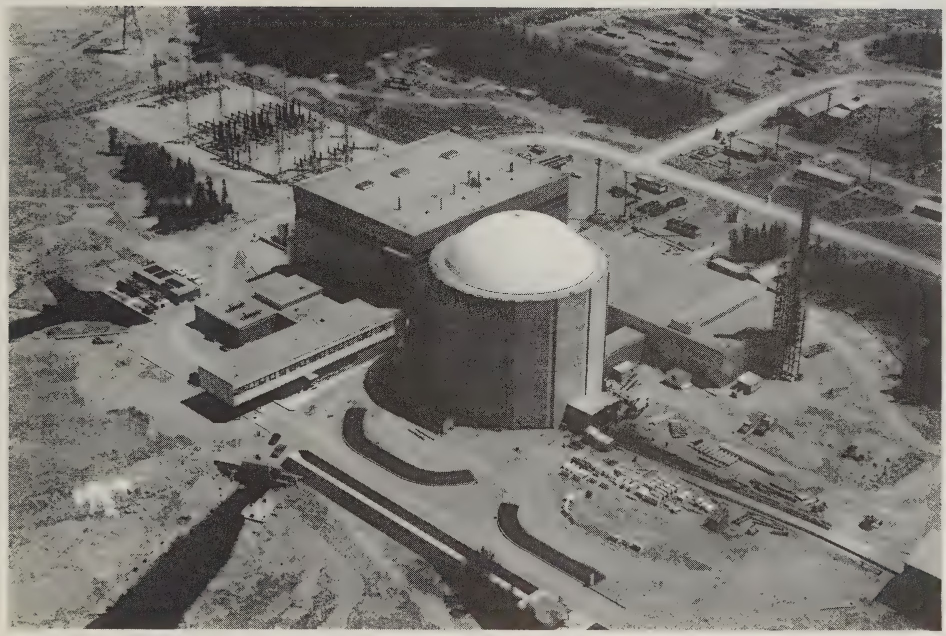
Today, Atomic Energy of Canada Limited (AECL) operates Canada's main atomic research centre, the Chalk River Nuclear Laboratories (CRNL) and the new Whiteshell Nuclear Research Establishment (WNRE). AECL has a Power Projects Division in Toronto and a Commercial Products Division in Ottawa. The main objective of the company is the development of economic nuclear power, though considerable emphasis has been placed on fundamental research.



Nuclear Power Demonstration — NPD

In co-operation with the Canadian General Electric Company Limited and the Hydro-Electric Power Commission of Ontario, Atomic Energy of Canada Limited (AECL) has built a natural uranium-fuelled, heavy-water-moderated power station near Rolphton, Ontario. This experimental plant, which produces 20,000 kilowatts of electricity, has successfully demonstrated the Canadian power reactor concept and gives great promise for the full-scale, 200,000-kilowatt Canadian Deuterium Uranium (CANDU) station; designed jointly by AECL's Power Projects of Ontario and the Ontario Hydro, it is now nearing completion at Douglas Point, on the Eastern shore of Lake Huron.

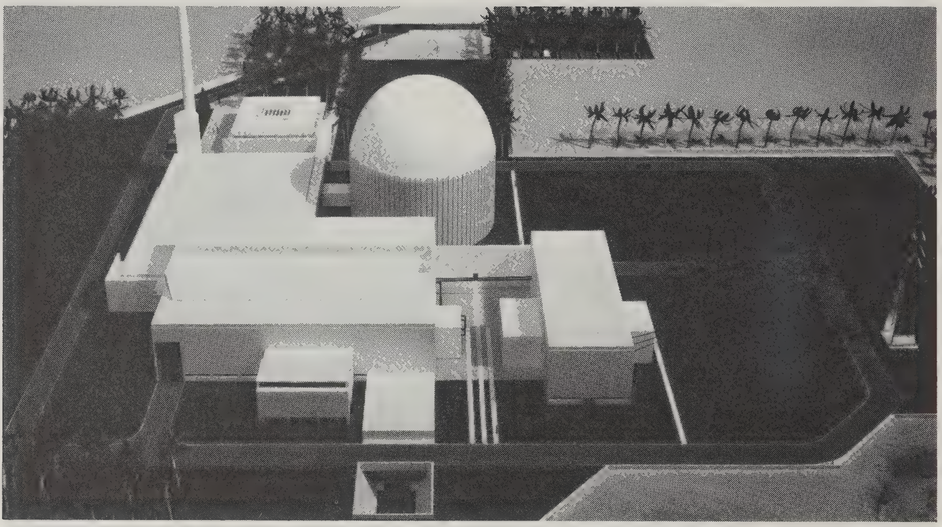
The same design team is now working on 500,000-kilowatt units, and it seems likely that the construction of a two-unit, one million-kilowatt generating station will be Canada's next step towards competitive nuclear power.



Aerial View of Douglas Point

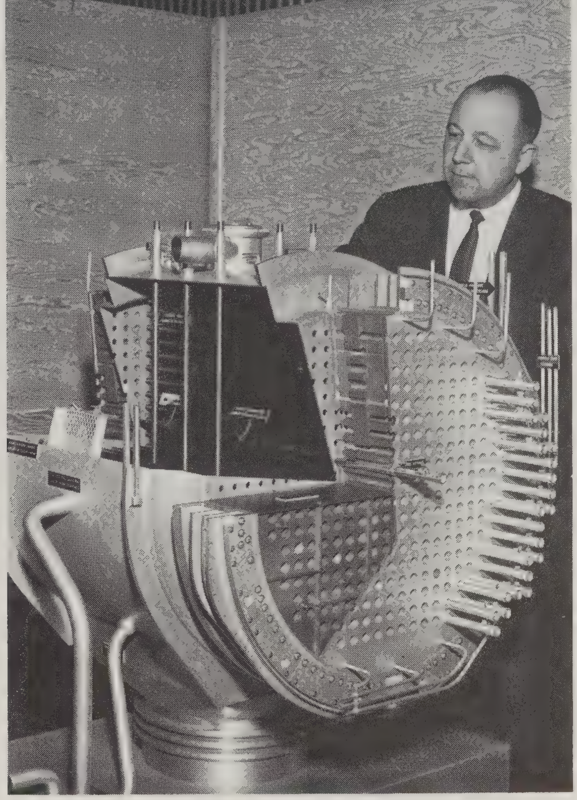
Canada has also pioneered in the medical and industrial applications of radioactive isotopes. Commercial Products Division of Atomic Energy of Canada Limited manufactures a variety of therapy units using cobalt-60 or cesium-137 as a radioactive source, as well as three different models of "Gammacell" and "Gammabeam" irradiators for industrial research and other non-therapeutic uses.

More than 320 therapy units have been installed in 40 countries and a mobile demonstration irradiator has been used since 1961 to demonstrate the feasibility of using irradiation to inhibit sprouting in vegetables. Sales of isotopes, services and associated equipment exceed $4 million per year.



Scale Model of
Karachi Nuclear Power Project

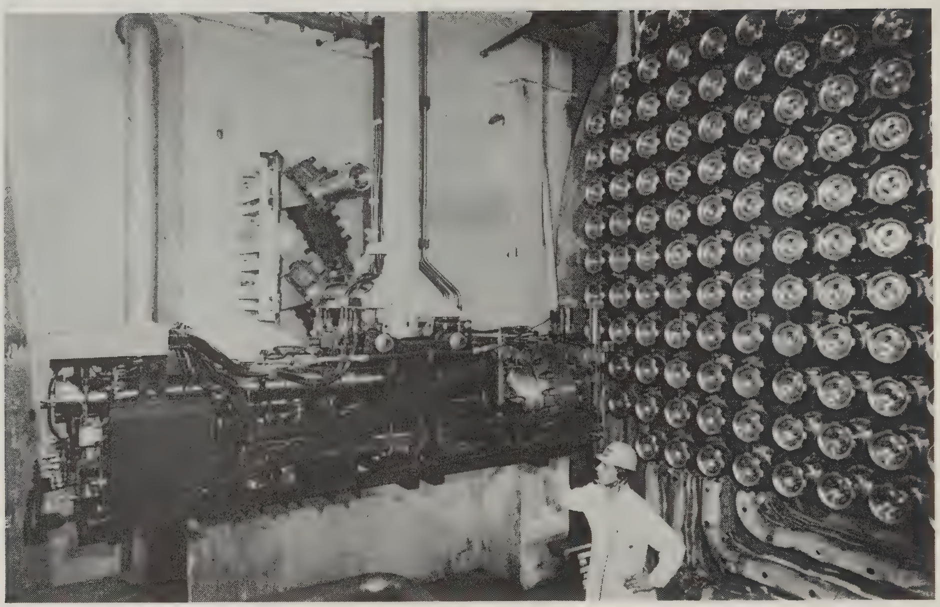
In the international field Canada's major project has been the Canada-India Reactor (CIR) formally opened at Trombay, India, in 1961. An improved version of the NRX reactor, CIR was built as a joint project under the Colombo Plan. In addition to providing this reactor, Canada is giving extensive technical assistance to India, including the training of Indian personnel at Chalk River. Under a more recent agreement between the two governments, Canada and India will co-operate in the construction of a 200-megawatt nuclear power station of the CANDU type, to be located at Rana Pratap Sagar, in Rajasthan State. Canada will provide the design, detailed working drawings and specifications of the station up to the steam-raising equipment, while India will provide the design for the rest of the project.



Cut-away Model of the CANDU Reactor

The design and manufacture of equipment for electrical power generation has been for more than 60 years a major field of interest for the Canadian General Electric Company Limited (CGE).

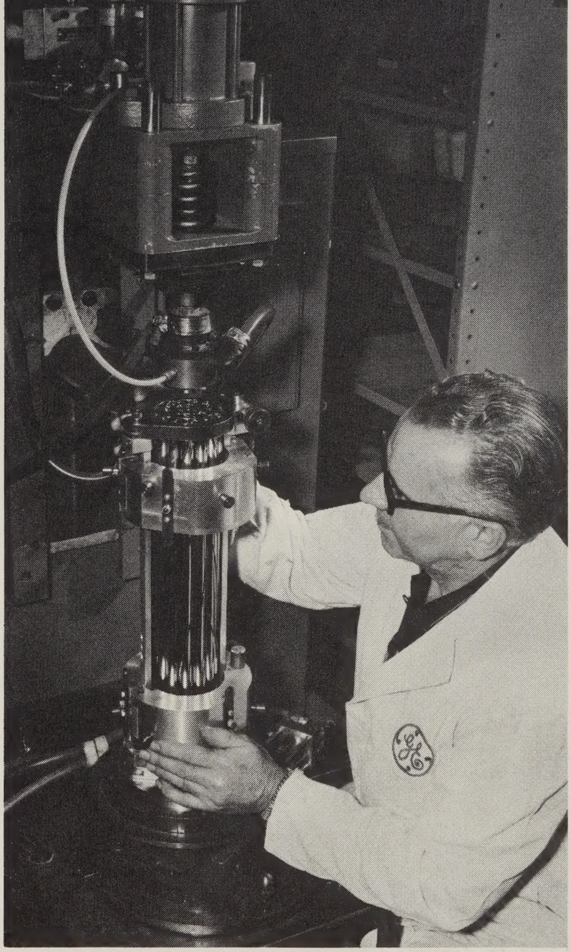
The Civilian Atomic Power Department of the company was established to participate in, and to contribute to the development of nuclear energy for peaceful purposes. It has since grown to be one of Canada's leading industrial organizations in the nuclear power field, employing a staff of more than 300 experienced physicists, metallurgists, engineers, chemists and other skilled technical personnel with excellent facilities for the design and development of nuclear reactor components and systems.



NPD Reactor Vault
Prior to Station Stand-up

Canadian General Electric Company's well-equipped Development Laboratory provides facilities for heat transfer and hydraulic flow experiments, wear and corrosion studies, rigs for prototype component testing and a metallurgical laboratory specially equipped for investigation of the fundamental properties of construction materials for nuclear reactors.

CGE's Civilian Atomic Power Department has its own specialized manufacturing facilities for reactor fuel, and utilizes the extensive manufacturing facilities of the whole company for other reactor components and conventional equipment.



19-Element Fuel Bundle Being Assembled in Welding Jig

The Civilian Atomic Power Department of the Canadian General Electric Company has recently completed a major nuclear fuel program which included the design, development and manufacture of nuclear fuel for the NPD and Douglas Point stations. A design, development and manufacturing program is nearing completion for the organic test reactor WR-1, and design and development work is in progress for the fuel for the one million-kilowatt Pickering Nuclear Generating Station.

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